Modeling from a Tropical State of Mind

Research Highlight

Scientists have long known that global climate models struggle to accurately simulate tropical storms and the clouds they produce in different kinds of meteorological states. Research has shown that tropical weather patterns can be classified into eight such states, including two monsoon states (active monsoon and break monsoon). Additional research comparing a range of global climate models with observations indicated that the models have more trouble simulating the break monsoon. In simulating the drier conditions of the break monsoon, global climate models gave completely different results about whether it is stormy, the time of day the storms occur, and other important factors. With these limitations in mind, researchers used smaller-scale cloud process models to provide insights into possible ways to improve the global models.

Understanding how global climate models simulate tropical weather and clouds allows scientists to pinpoint and resolve areas of concern. For example, researchers found that models in which storm development is more sensitive to atmospheric humidity are more likely to simulate the break monsoon accurately. Cloud-scale modeling also provided insight into several of the physical processes important to tropical weather patterns, such as the effects of downdrafts, the cold pools of air they create, and the broad shields of anvil clouds that accompany some storms. These types of information lead to more robust models of tropical weather patterns, which regulate global climate and influence the severity and duration of precipitation not only in the tropics but also as far away as the U.S.

To identify the states of tropical weather, scientists started with information from a meteorological analysis, which combines available observations with weather prediction models to identify shorter-term weather patterns over a large area. They input these data into a neural network—a statistical way of dealing with large quantities of disparate data to find recurring patterns. They centered their area of analysis on Darwin, Australia, because of its strategic location for observing tropical weather variations and because of the availability of extensive DOE ground-based observations at the ARM site there. They then looked for atmospheric states in which cloud properties were stable over time and distinct from every other state.

To compare the ability of various global climate models to simulate these tropical atmospheric states, scientists then used data from a large DOE field experiment called the Tropical Warm Pool-International Cloud Experiment, or TWP-ICE, to compare results against observations of actual tropical weather. Data from the field experiment also made cloud-scale modeling possible and helped scientists identify potential ways to improve the global models.

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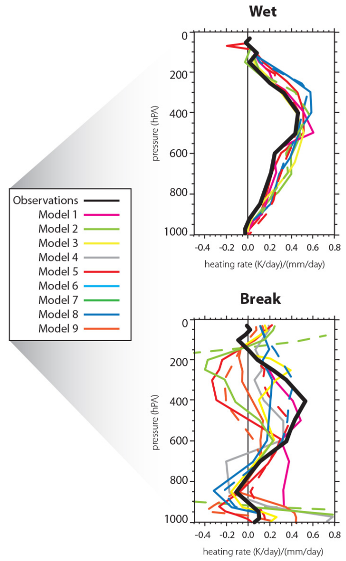

Coming to agreement: Researchers have determined that tropical weather patterns include several states, including wet and break monsoons. Further research is helping identify ways to improve global climate models, which tend to agree with observations on how storms heat the atmosphere in the wet monsoon state but struggle to accurately model storms in the break monsoon state.

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Reference(s)

Mrowiec AA, C Rio, AM Fridlind, AS Ackerman, AD Del Genio, OM Pauluis, AC Varble, and J Fan. 2012. "Analysis of cloud-resolving simulations of a tropical mesoscale convective system observed during TWP-ICE: Vertical fluxes and draft properties in convective and stratiform regions." Journal of Geophysical Research, 117, D19201, doi:10.1029/2012JD017759.

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Cloud Life Cycle